Pre-Conference Activities

Article: Hamming It Up on the ISS

You see it on television: NASA officials contact astronauts on the Space Station through radio hookups. There's another way to keep in touch with crewmembers, though, and anyone with a ham radio system can participate.

Amateur radio, also called ham radio, has become the fun way for anyone to communicate with the Space Station astronauts. Anyone with a scanner can listen to the communications that take place between Earth and space, and if you have a transmitter, you can get in on the conversations.

"The whole point is to spark an interest in science and technology," says Frank Bauer, chief of the Guidance and Navigation Control Center at Goddard Space Flight Center in Maryland. "Communicating with ham radio started with the Space Shuttle program in 1983, and by the mid 80s, we had several school group interaction activities going.

"This opens new doors for access to the astronauts," Bauer says. "Before, only the president or other VIPs could talk with the astronauts while they were in space. Now with an amateur radio license, you can talk too. The ham radio project was the first effort to allow astronauts to talk with the general public."

To talk with the astronauts, you'll need to know several important bits of information, says Paul Dumbacher, a propulsion test engineer at Marshall Space Flight Center in Alabama, who also enjoys ham radio. Everything you'll need to know to get started is listed at the Amateur Radio on the International Space Station (ARISS) web site.

"The important things to know are when the Space Station will be over your location, what frequency the astronauts transmit on, and what the crew's schedule is," Dumbacher says. Information at the ARISS web site will tell you the call signs of the astronauts, so you'll know whom you're listening to, Dumbacher says. Taking the time to learn a bit of basic amateur radio lingo will help you understand the proceedings.

"Conversations begin with the sender's call signs and then a signal report," Dumbacher says. "Then someone is asked what their QTH is; that's short for your location. If an astronaut says, "QRZ," that means he's opening the conversation up for the next interested participant. It takes a while to learn the language of ham radio, but it's a wonderful opportunity to make contact with a piece of history. You can see NASA on TV, look at maps, and they don't seem real. But to go outside and look up and see the Space Station or hear them talking on the radio, that's real. To talk with people on a man-made object launched by a rocket is all very amazing."

While individuals can monitor Space Station transmissions from home, school groups can make it a class project and work closely with ham radio operators and NASA staff members to schedule a conversation with the astronauts. The ARISS project was started with that goal in mind.

"There are many options open to contacting the astronauts through amateur radio," Bauer says. "If schools can't contact the ISS from their location. They can use a program called Tele-bridge, which is a phone bridge set up to communicate from telephone to short wave radio. We've had groups in Australia and South Africa use Tele-bridge to make their connections."

It's a challenge to be sure the school group is ready to communicate at the precise moment the Space Station is overhead, Bauer says. The equipment can't be too simple or too complex, you have to have the orbit information right. The children have to be prepared to conduct their conversations efficiently. But it's all worth it when it works."

The actual contact with the astronauts is the top of the pyramid, Bauer says. It's the peak experience. "But the foundation under that pyramid peak is the remarkable part. The learning required to prepare for this contact-antenna, radio, orbit, press releases, geography, trial and error-it all shows the children how demanding this process is, and how much knowledge is required for success."

It's a living example of why mathematics and science are good things. "It shows practical use of formulas," Dumbacher says. "Students learn about complex ideas like Doppler Shift and trajectory paths. It shows that even addition and subtraction get you to important points. Science matters; without science we wouldn't have ISS; we wouldn't understand weather, we wouldn't understand basic functions of everyday life. And there's no better way to learn it than by doing it."

If you get the opportunity to make contact with Shuttle or Space Station astronauts, Dumbacher has one bit of advice. "Be sure to get a QSL card. That's a card NASA will send you proving that you talked to an astronaut. There's information about getting it on the ARISS web site. You'll want to be able to put that up on your bulletin board and tell everyone."

Courtesy of NASA's Space Operations Mission Directorate

Radio Waves

Teacher Sheet(s)

Objective: Students will draw an electromagnetic spectrum and calculate frequency and wavelength.

Level: 9-12
Subjects(s): Physical Science, Physics, Mathematics, Technology
Prep Time: Less than 10 minutes
Duration: 40 minutes
Materials Category: Common Household

National Education Standards
Science: Unifying Concepts, Physical Science
Math: Algebra
Technology (ITEA): 2, 3, 17

Materials:
(Per group)

- Paper
- Pencil
- Calculator

Pre-Lesson Instructions:
None

Background Information:
None

Guidelines:

1. Read the article, "Hamming It Up On ISS." Discuss the use of amateur radios and how they are being used to communicate to astronauts.

2. Explain the following:

   MF - medium frequency between 300 to 3000 kHz
   HF - high frequency between 3000 and 30,000 kHz
   VHF - very high frequency between 30 and 300 MHz
   UHF - ultrahigh frequency between 3 x 108 Hz and 3 x 109 Hz

3. Review equations:

$\lambda = v/f$
$T = 1/f$
$v = d/t$

4. An electromagnetic spectrum has been provided as a reference. You may wish to share this with the students for the student procedure section.

Discussion/Wrap-up:
None

Extensions:

1. 104.3 MHz FM
   68 KHz AM
   98.1 KHz AM

2. Change MHz to Hz — 99.5 MHz = 99.5 x 106 Hz
   $\lambda = v/f = (3.0 \times 10^8 \text{ m/s})/(99.5 \times 10^6 \text{ Hz}) = 3.02 \text{ m}$

3. AM radio waves have longer wavelengths than FM radio waves. AM waves can bend around hills and buildings. The shorter wavelength FM radio waves are blocked by large objects.

4.
   a. T = 1/f
      0s = 1/f
      2 m/s = f
   b. 165

5. T = 1/f
   = 1/242 Hz
   = .00413223 s = 4.13 ms

6.
   a. v = d/t
   (450m)/(2.5s) = 180m/s

   b. T = 1/f
   1/520 Hz = .001923s = 1.92 ms

   c. $\lambda = v/f$
   (180 m/s)/(520 Hz) = 0.3462 m

7. AM means amplitude modulation.

8. FM means frequency modulation.

9. Modulation means the process of impressing information (code, speech, video, data, etc.) on to a higher frequency carrier.

Radio Waves

Student Sheet(s)

Objective:
Students will draw an electromagnetic spectrum and calculate frequency and wavelength.

Materials:

- Paper
- Pencil
- Calculator

Background:

The waves in the electromagnetic spectrum that have the lowest frequencies and longest wavelengths are called radio waves. Radio waves are produced when charged particles move back and forth in antennas. Waves coming out of the radio are sound waves. These are different than radio waves. Radio waves are the waves used to transmit information from the antenna of a broadcasting station to the antenna on your radio or television.

AM radio stations broadcast on frequencies between 535 kilohertz and 1605 kilohertz. FM radio stations broadcast on frequencies between 88.1 megahertz and 107.9 megahertz. Because FM radio waves are shorter, they don't diffract as much around buildings, and aren't received as well as AM radio waves, particularly in mountain regions or canyons. This is why many localities have poor FM reception, while AM reception comes in loud and clear.

AM stands for amplitude modulation. In this method, the information is put into a radio wave by varying the amplitude. For example, if all we wanted to do was send 1s and 0s, we could have just two different levels of amplitude that correspond to these numbers—1 being high, 0 being low.

FM stands for frequency modulation. This time the amplitude is kept constant; it is the frequency that is varied.

Ham radios send and receive radio transmissions. Ham radios use electricity to operate, however, many can also run on batteries. When terrible storms devastate communities, ham radios are sometimes the only communication in and out of the affected area.

Procedure:

1. Draw a chart of the electromagnetic spectrum covering 100 kilohertz to 1000 megahertz.

2. Label the MF, HF, VHF, and UHF portions of the spectrum on your chart.

3. Locate on your chart at least eight radio services such as your favorite AM and FM commercial broadcast stations, CB, television, and amateur radio.

4. Using the formula, find the length of the radio waves of five of the items you listed on the chart.

$$\lambda = v/f$$

Questions:

1. Identify the following as AM or FM stations based on the frequency:

104.3 MHz	
68 KHz	
98.1 KHz	

2. A radio wave has a frequency of 99.5 MHz. What is its wavelength?

3. AM radio signals have wavelengths between 600 meters and 200 meters, while FM signals have wavelengths about 3 meters. Explain why AM signals can often be heard behind hills while FM signals cannot.

4. A sound wave has a wavelength of 0.80 meters and a velocity of 335 m/s is produced for 0.70 seconds.

    a. What is the frequency of the wave?

    b. How many complete waves are emitted in this time interval?

5. A sound wave has a frequency of 242 hertz. What is the time between successive wave crests?

6. A sound wave produced by a wild animal 450 meters away is heard 2.5 seconds later.

    a. What is the speed of sound in the air?

    b. The sound wave has a frequency of 520 Hz. What is its period?

    c. What is its wavelength?

7. What does AM stand for?

8. What does FM stand for?

9. What does modulation mean?